Climate Response and Radiative Forcing for Each Aerosol Species in CESM Prescribed from NCAR and Harvard Concentrations

Qiong Yang[1], Sarah Doherty[1], and Cecilia Bitz[2]

[1] Joint Institute for the Study of the Atmosphere and Ocean, University of Washington

[2]Department of Atmospheric Sciences, University of Washington

Thomas Breider[3], Loretta Mickley[3], and Daniel Jacob[3]

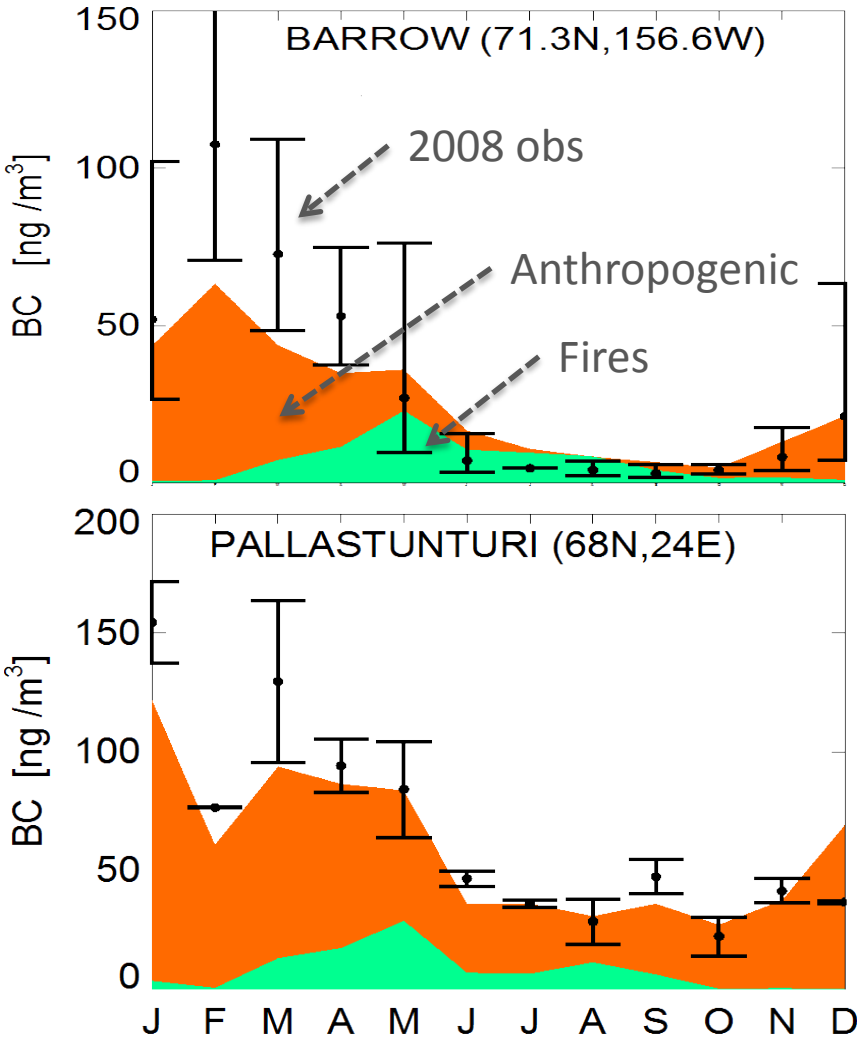
[3]Harvard University

Model experiment setup

- CESM v1.0.3 with CAM4
- NCAR: use year 2000 aerosol emissions

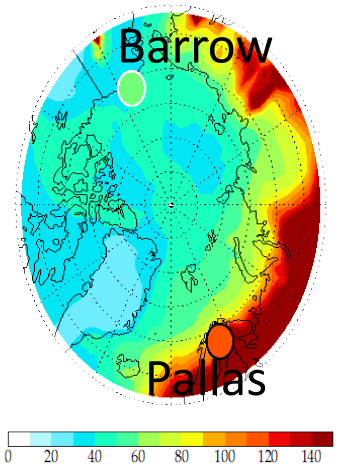
  Harvard: use 2008 aerosol mass concentrations from GEOS-Chem
- Aerosol radiative forcing (ARF) is instantaneous radiative forcing estimated by calling the radiative transfer module twice.

Observation Comparisons - BC

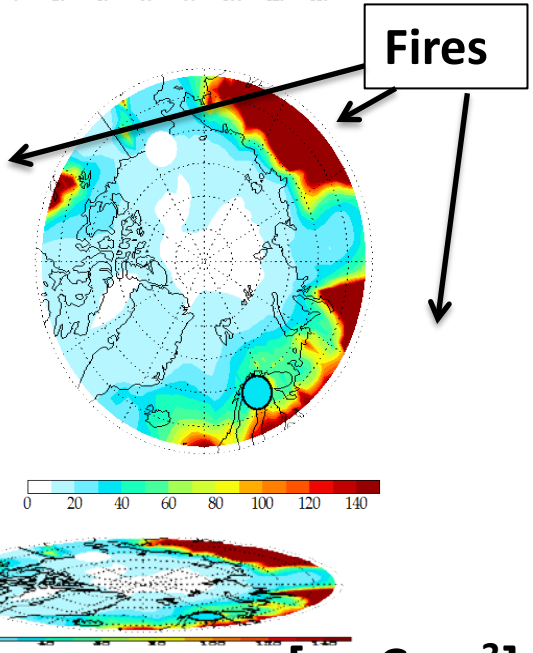


Source: Hyvarinen et al., 2011.

SURFACE BC SPRING



SURFACE BC SUMMER

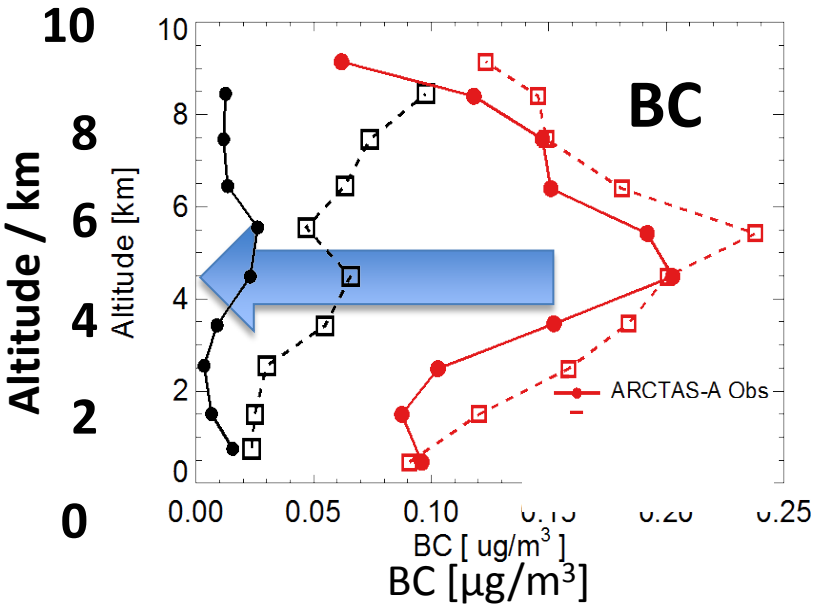


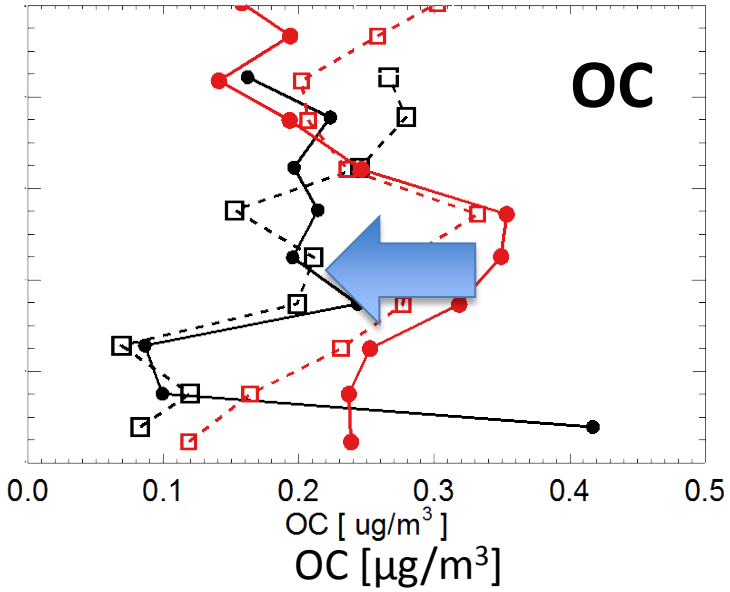
[ng C m^{-3}]

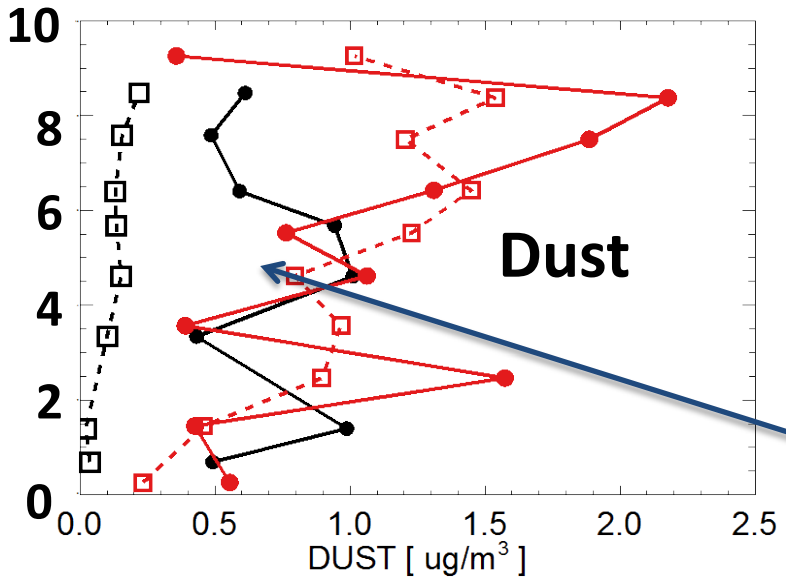
Higher BC over Eurasian Arctic in spring and summer

Comparison with DC-8 ARCTAS observations

The spring-summer decrease is greater for BC than OC and provides evidence for anth. source in ARCTAS-Spring





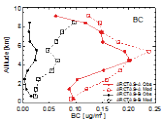


Main dust source in spring in model is Sahara

Low bias in summer

ARCTAS-Summer

ARCTAS-Spring

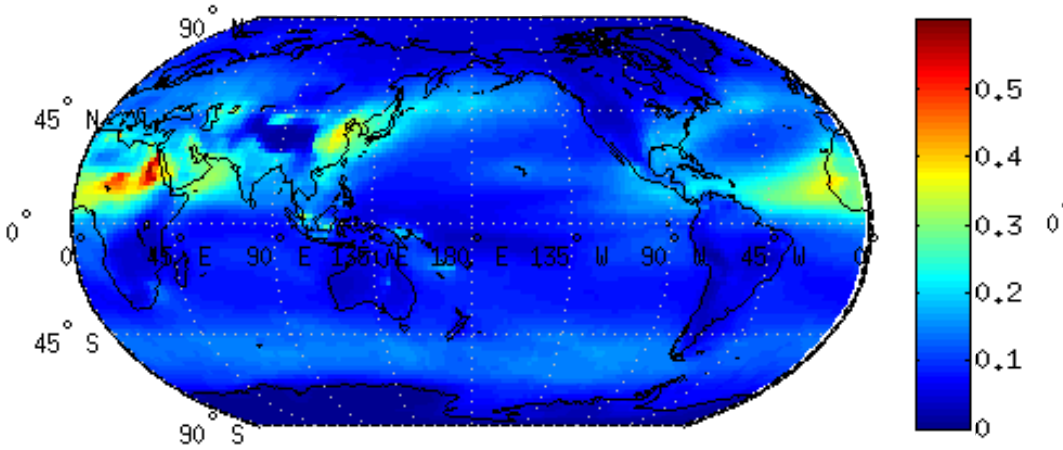


Obs

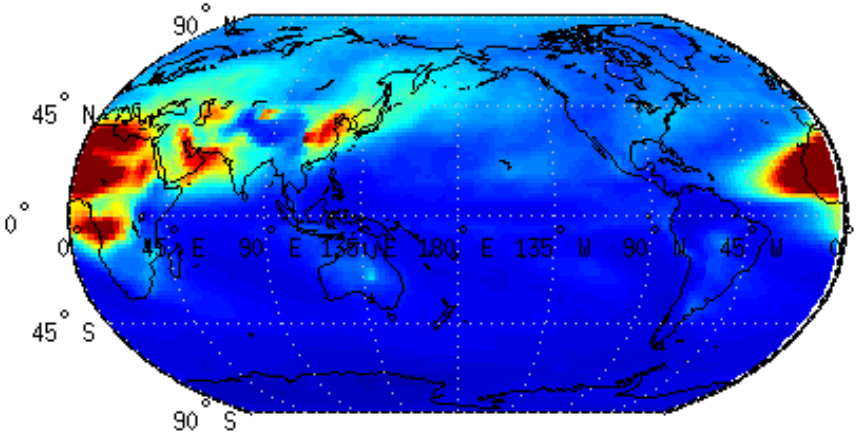
Model

Aerosol Optical Depth

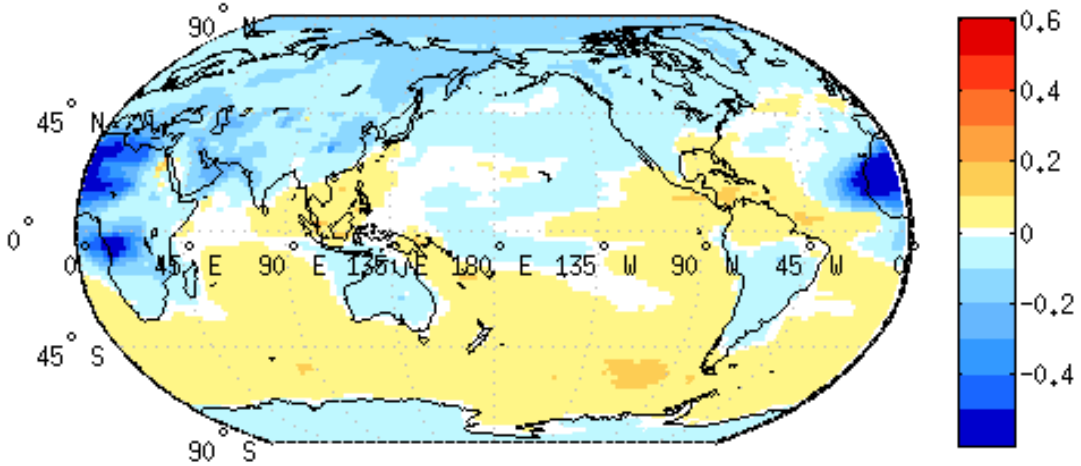
NCAR tau



Harvard tau

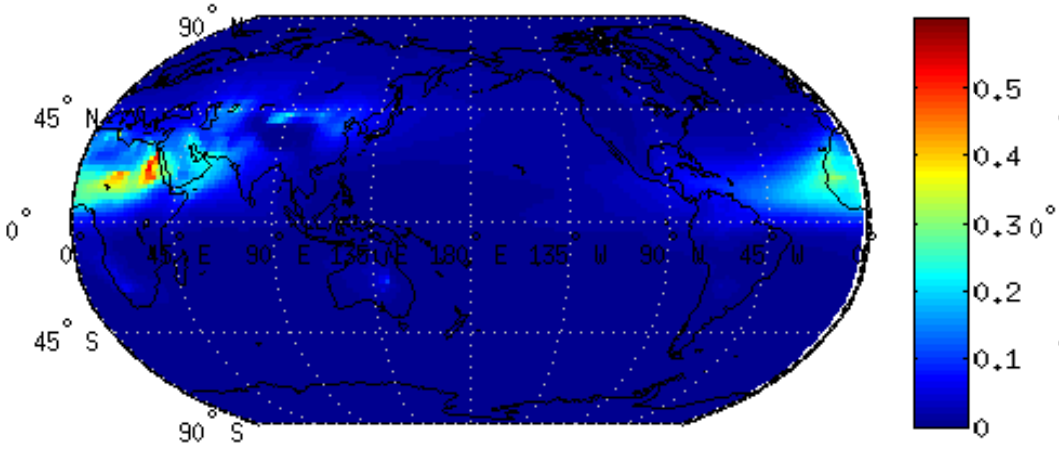


NCAR – Harvard tau

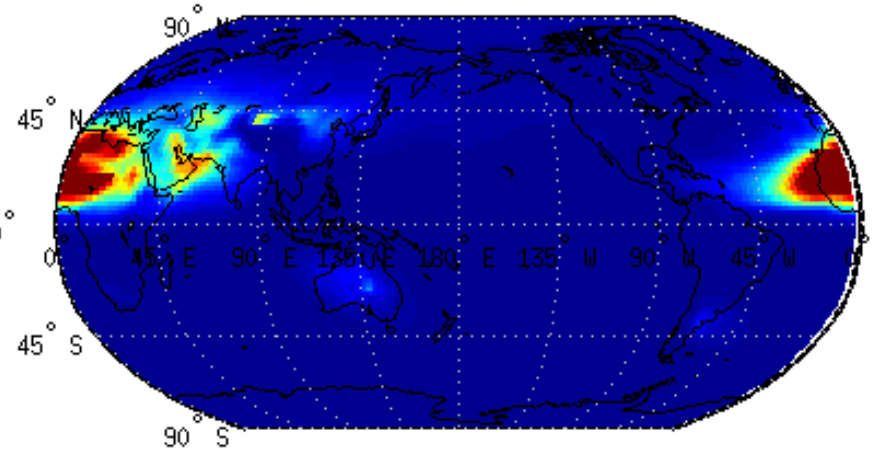


Dust: Optical Depth

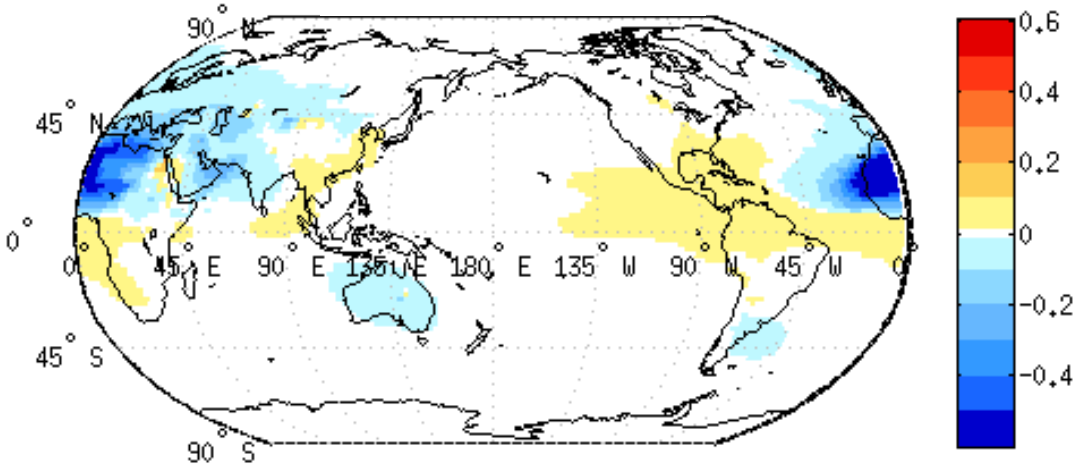
NCAR tau



Harvard tau

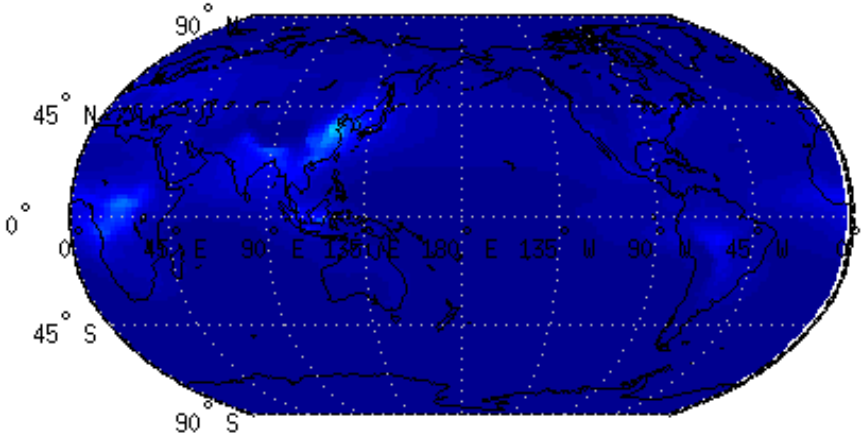


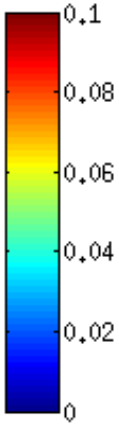
NCAR – Harvard tau



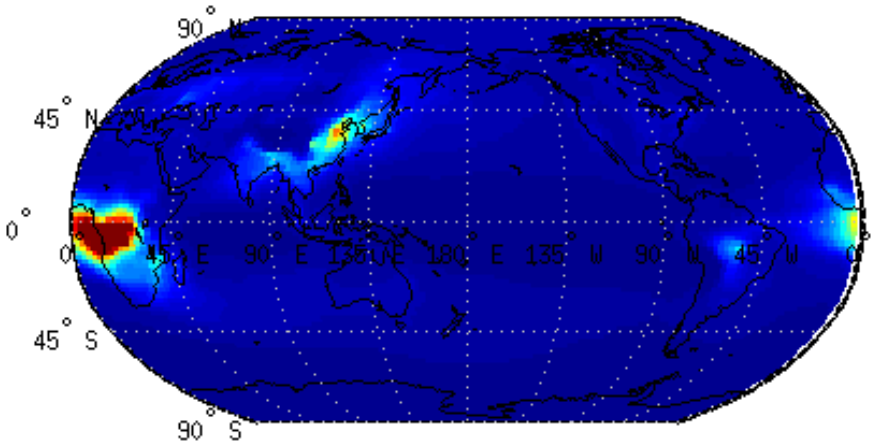
Black Carbon: Optical Depth

NCAR tau

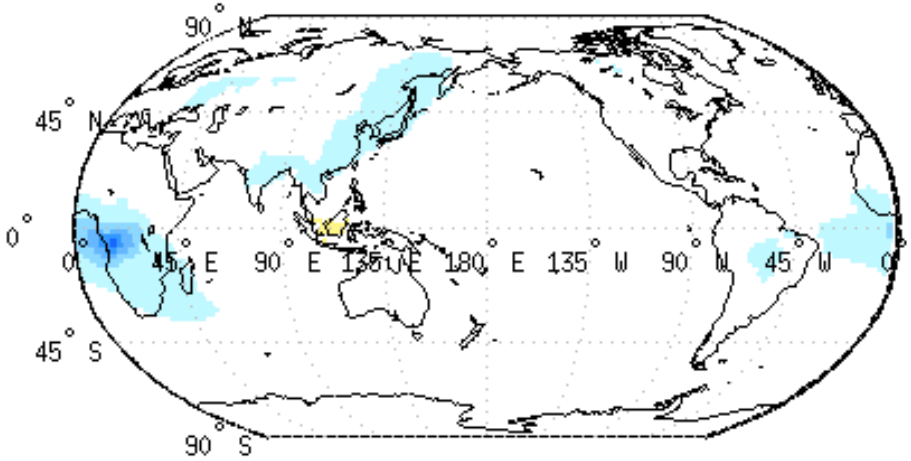


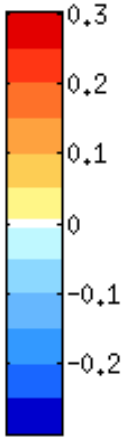


Harvard tau



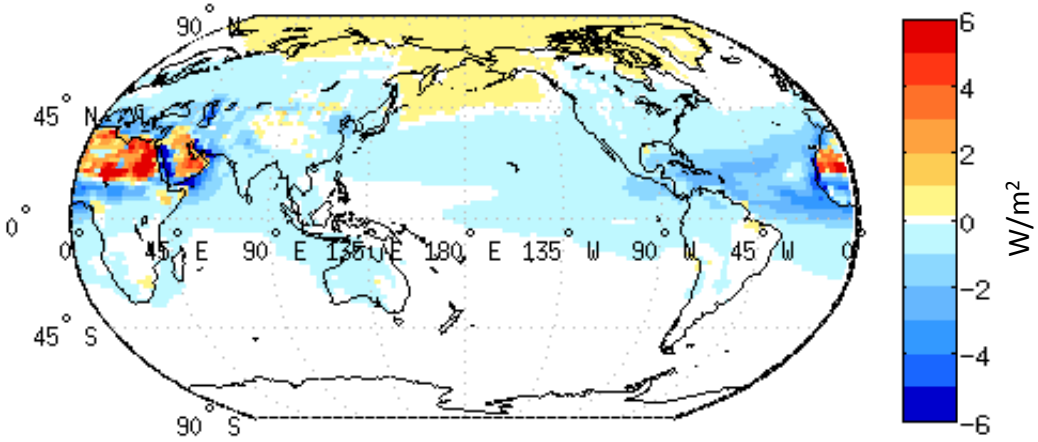
NCAR – Harvard tau



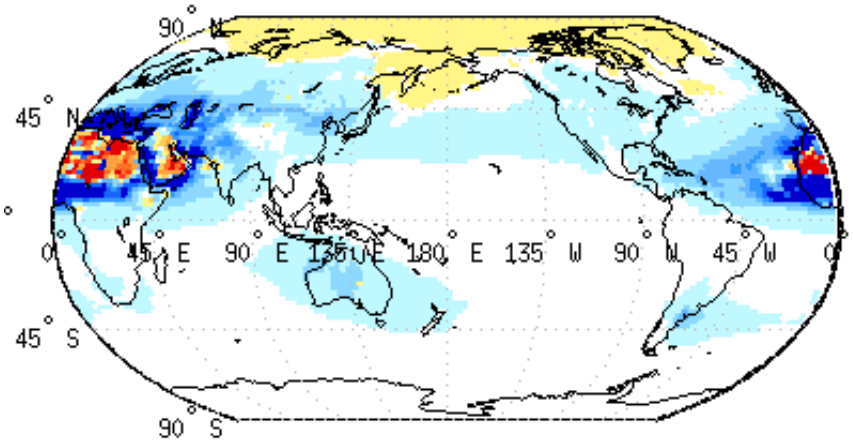


Dust: Radiative Forcing@ TOA

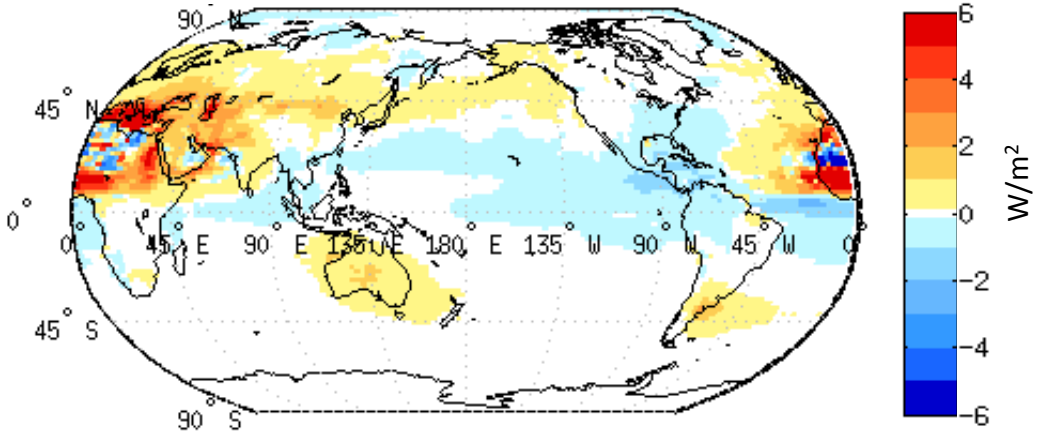
NCAR RF@TOA



Harvard RF@TOA



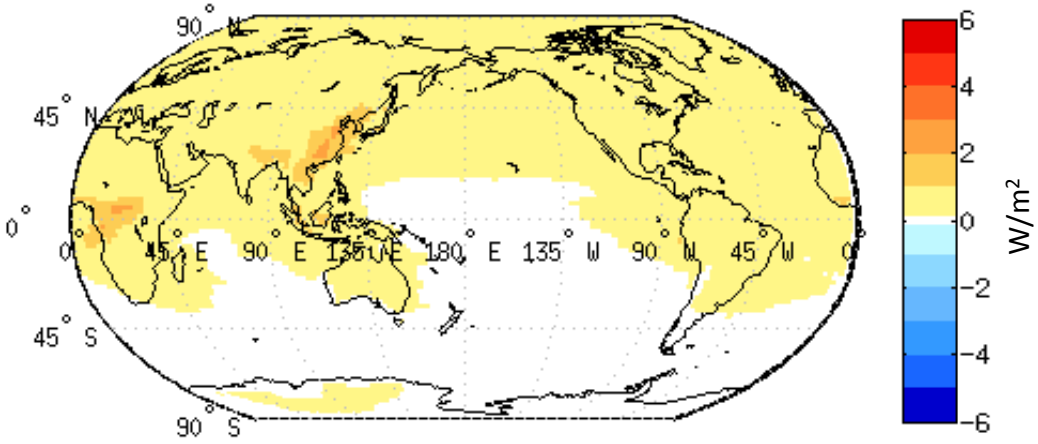
NCAR – Harvard RF@TOA



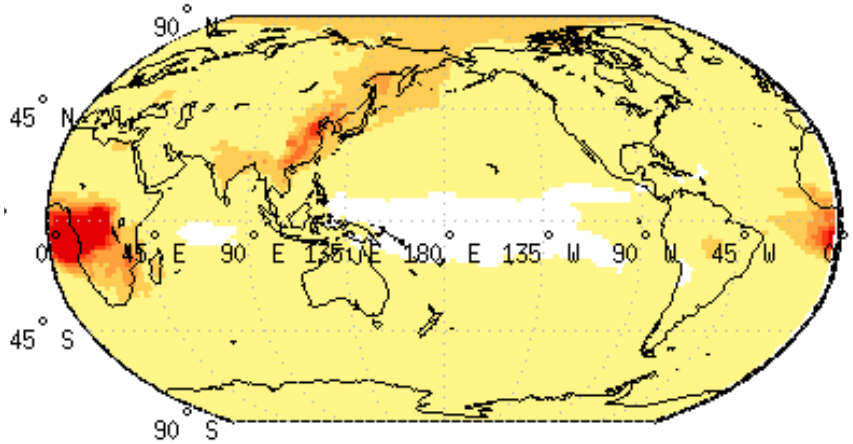
RF: radiative forcing

Black Carbon: Radiative Forcing@ TOA

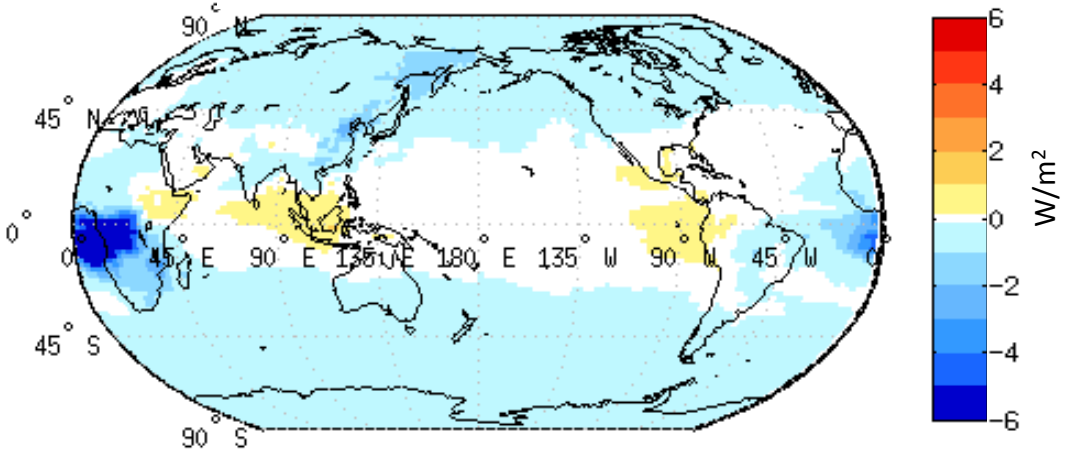
NCAR RF@TOA



Harvard RF@TOA

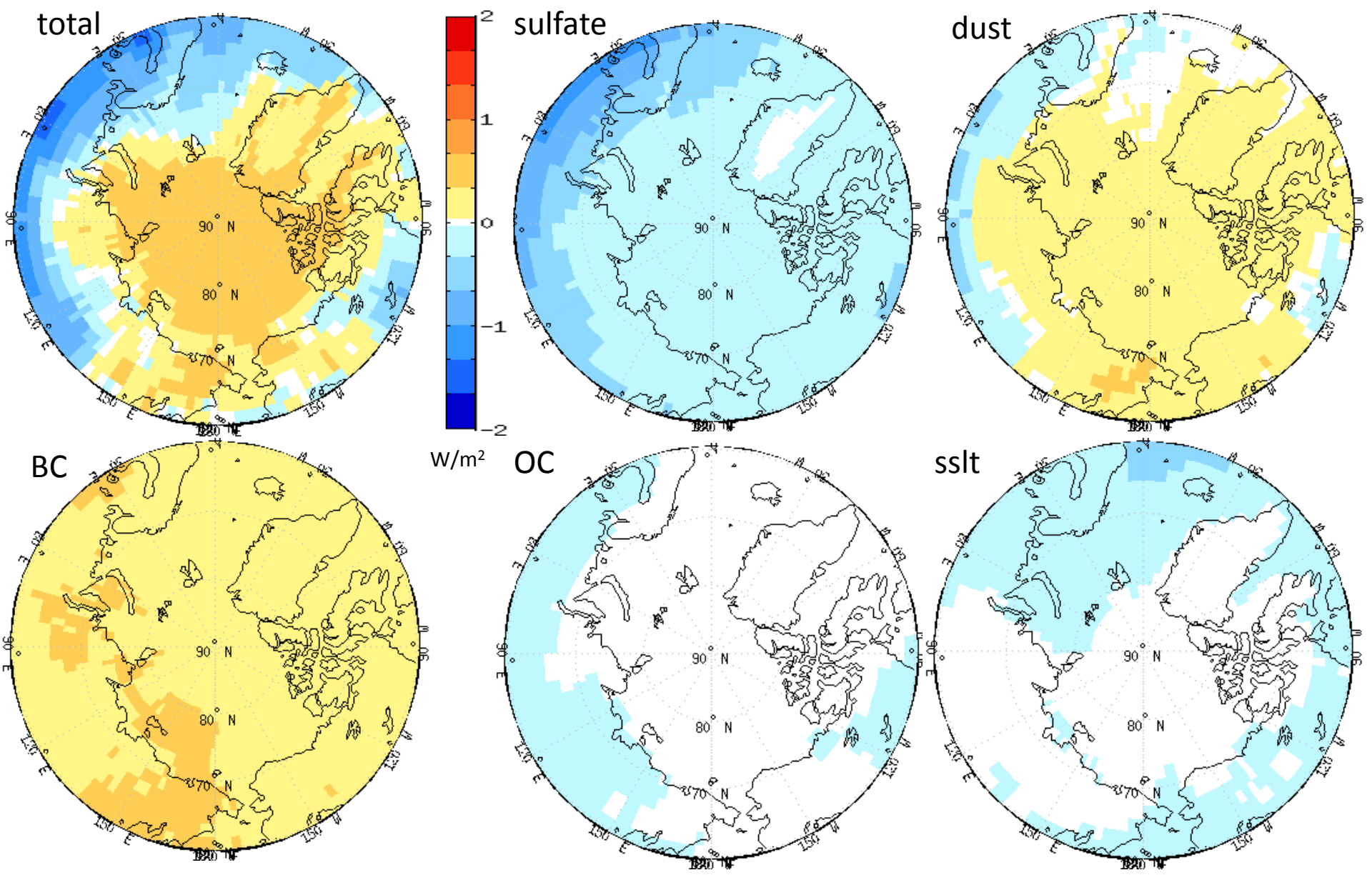


NCAR – Harvard RF@TOA

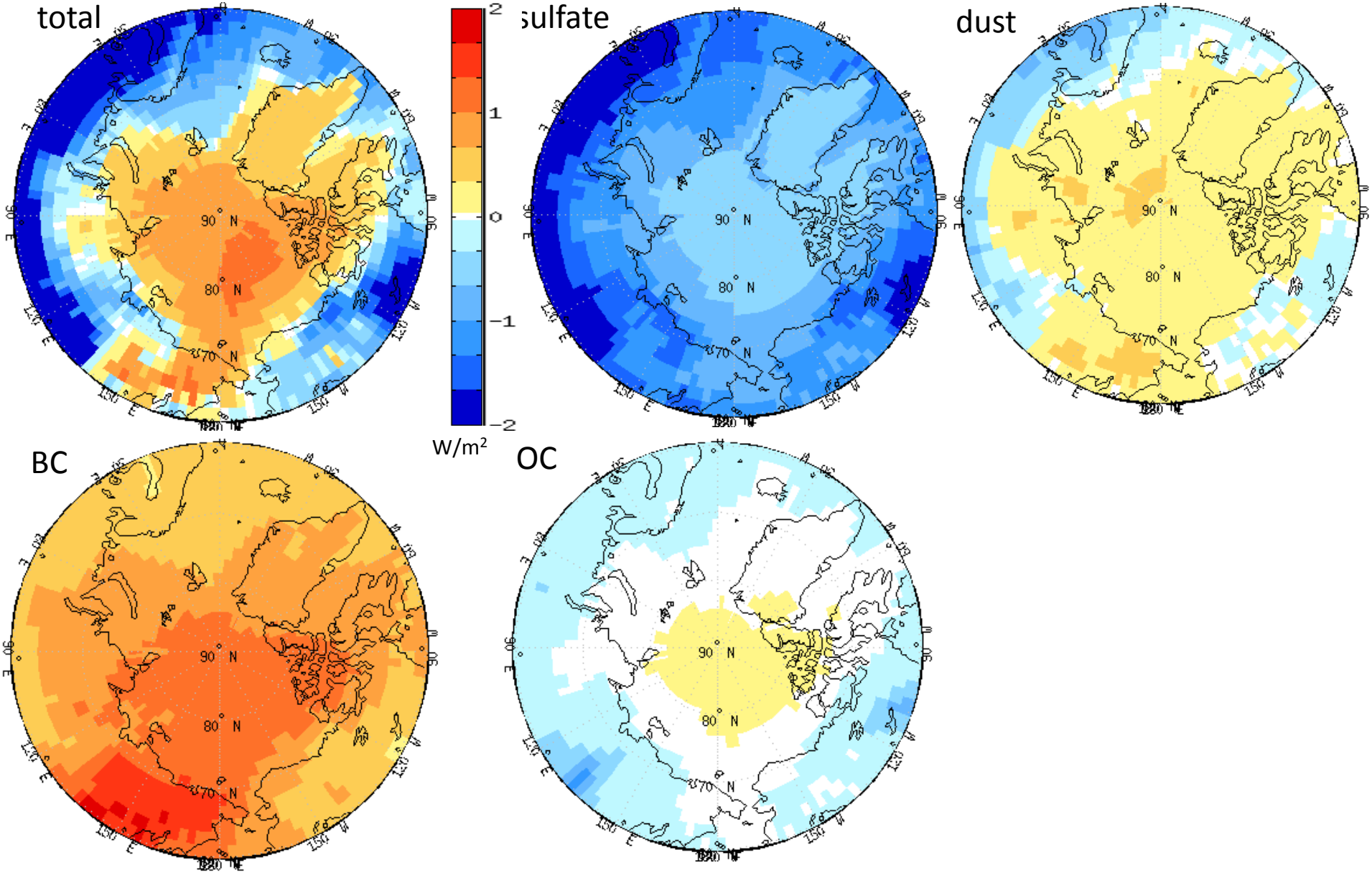


RF: radiative forcing

Radiative Forcing @ TOA in Arctic -- NCAR

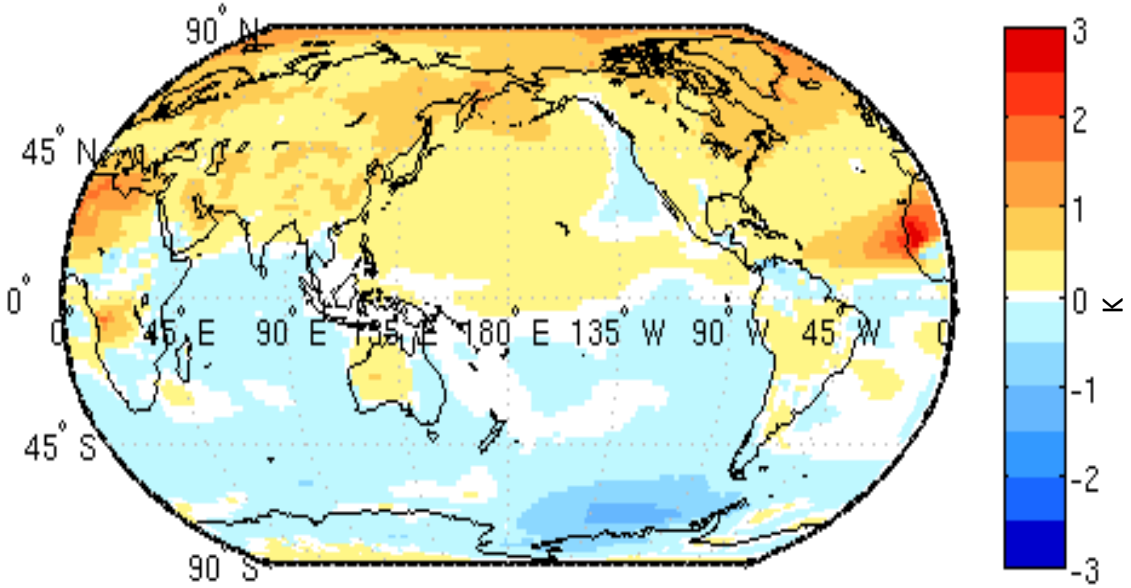


Radiative Forcing @ TOA in Arctic -- Harvard



Climate Response

TREFHT: NCAR - Harvard



TREFHT: surface air temperature at reference height

Climate Response

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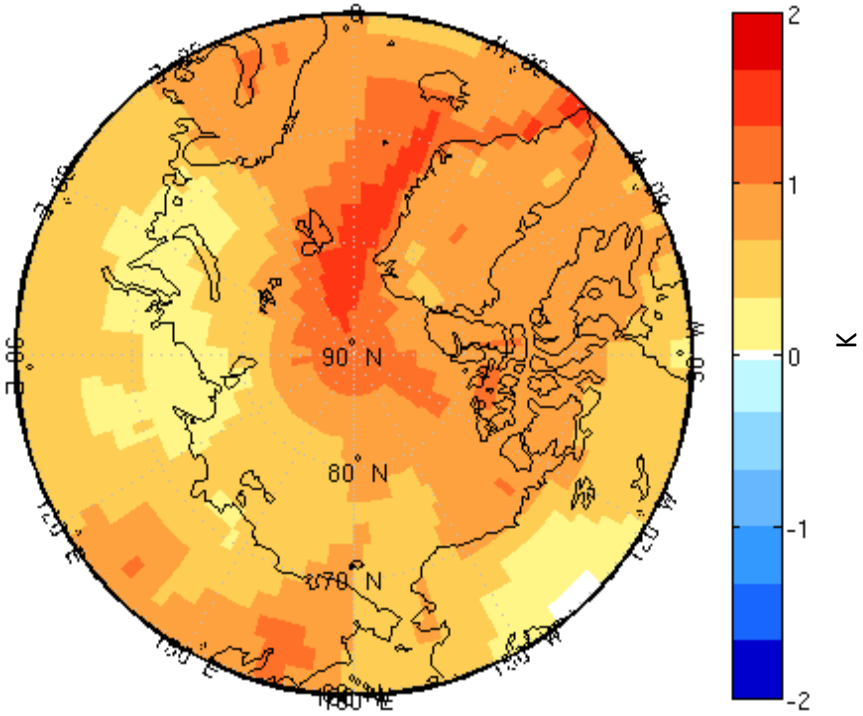


TREFHT: surface air temperature
at reference height

Summary

Harvard (or GEOS-Chem) concentrations for year 2008 has much higher aerosol concentrations than in NCAR concentrations for year 2000.

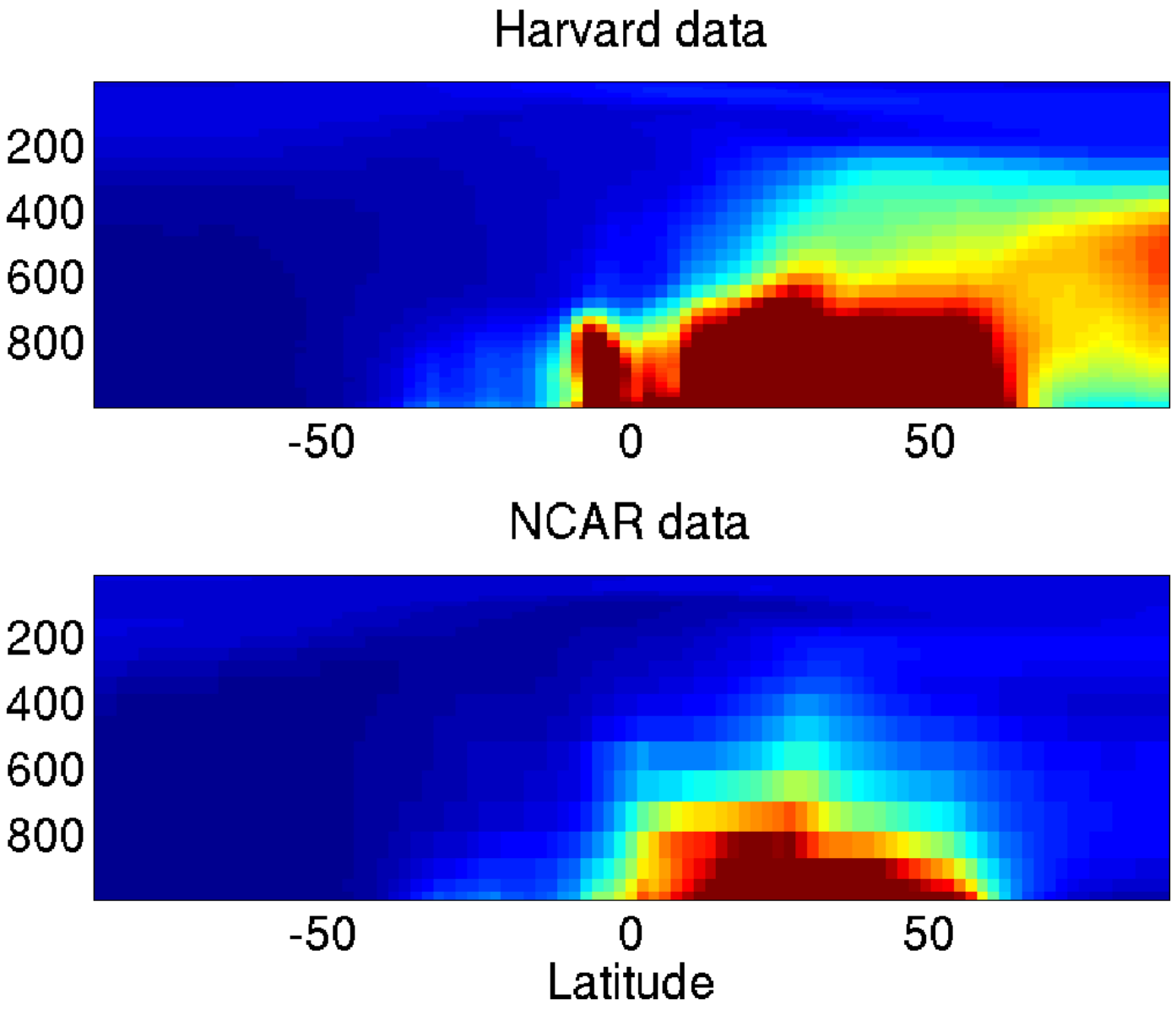
The RF for BC over the Sahara is in excess of 6 W/m^2, where NCAR is 1-2 W/m^2. In 2008 Harvard has >1 W/m^2 over the Arctic.

However, the global mean climate response is about the same for NCAR and Harvard data sets due to cancellation. But there are interesting hemispheric and regional differences.

The global mean climate differences are small in part because dust, sulfate, and OC effects oppose those from BC.

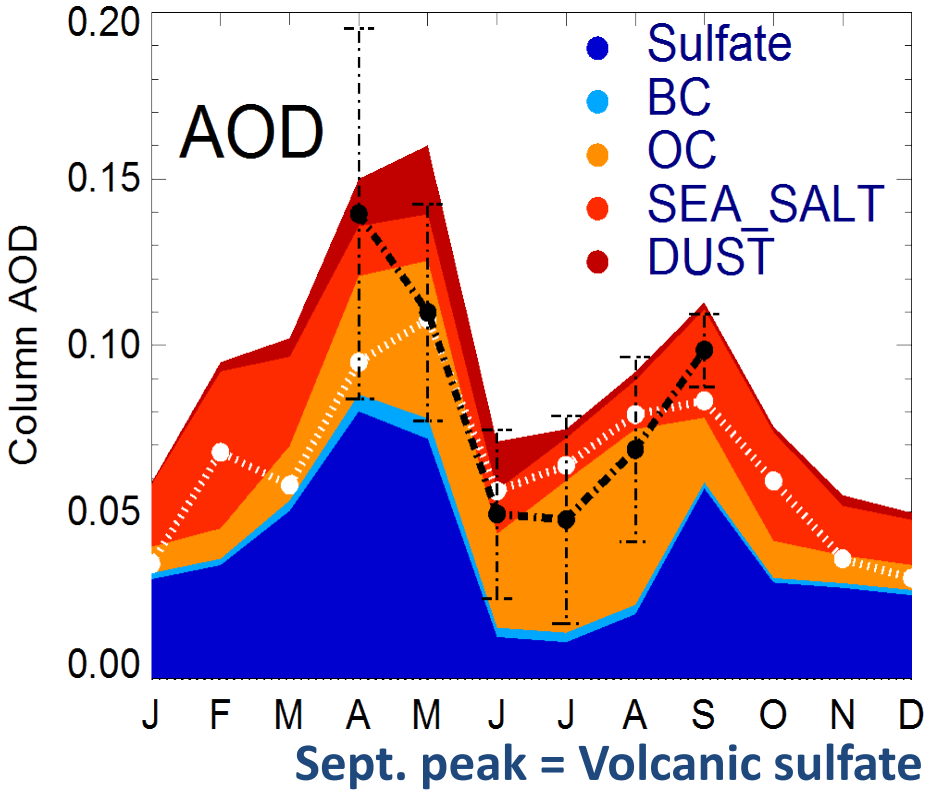
In the Arctic RF in the Harvard estimate is dominated by BC, but recall the Harvard estimate is for year 2008.

Spring BC Concentrations

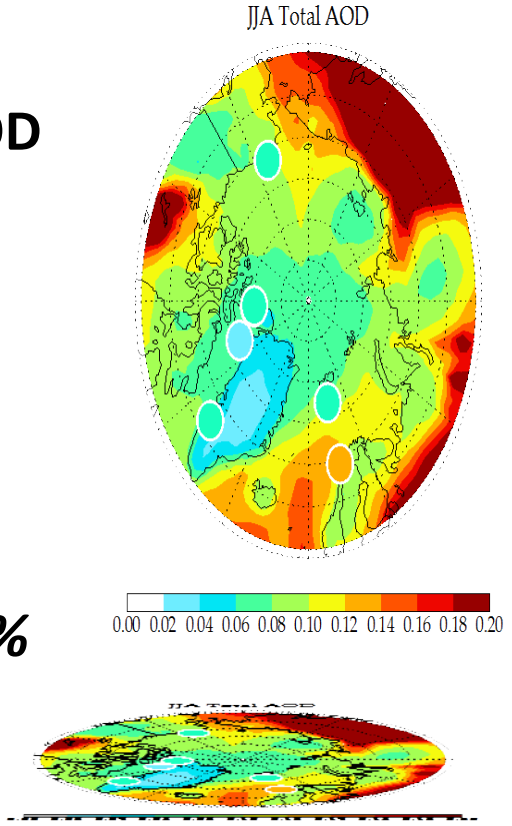


Comparison with Arctic aerosol optical depth (AOD) observations

AOD across 8 Arctic AERONET Stations



Summer AOD



Annual

R^2 = 0.56

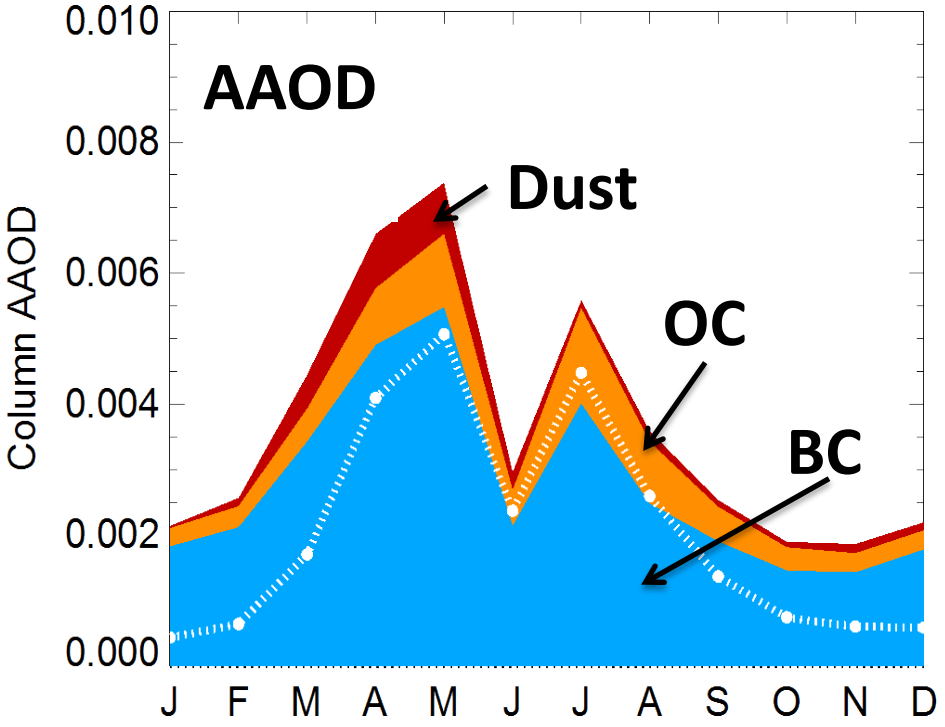
NMB = 26%

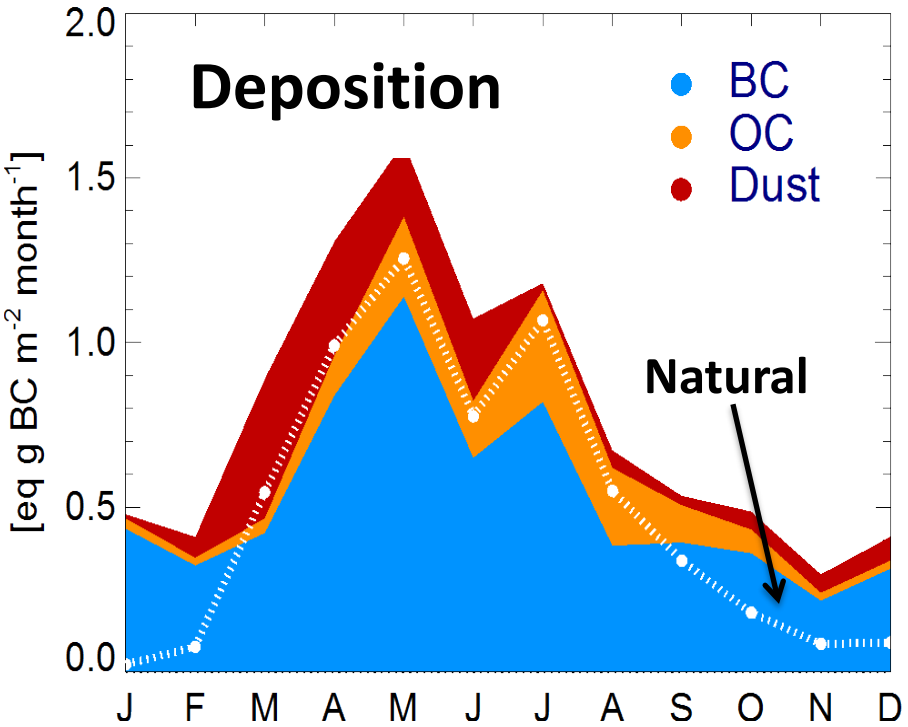
OC is the main AOD component in summer due to large open fire sources

Absorption AOD and deposition of absorbing species (>65N)

Absorption = Mass cpt (g m^{-3}) * Mass Absorption Efficiency (m^2 g^{-1})

[MAE BC=9.5m^2g^{-1}, OC= 0.27m^2 g^{-1}, Dust=0.03m^2g^{-1}]





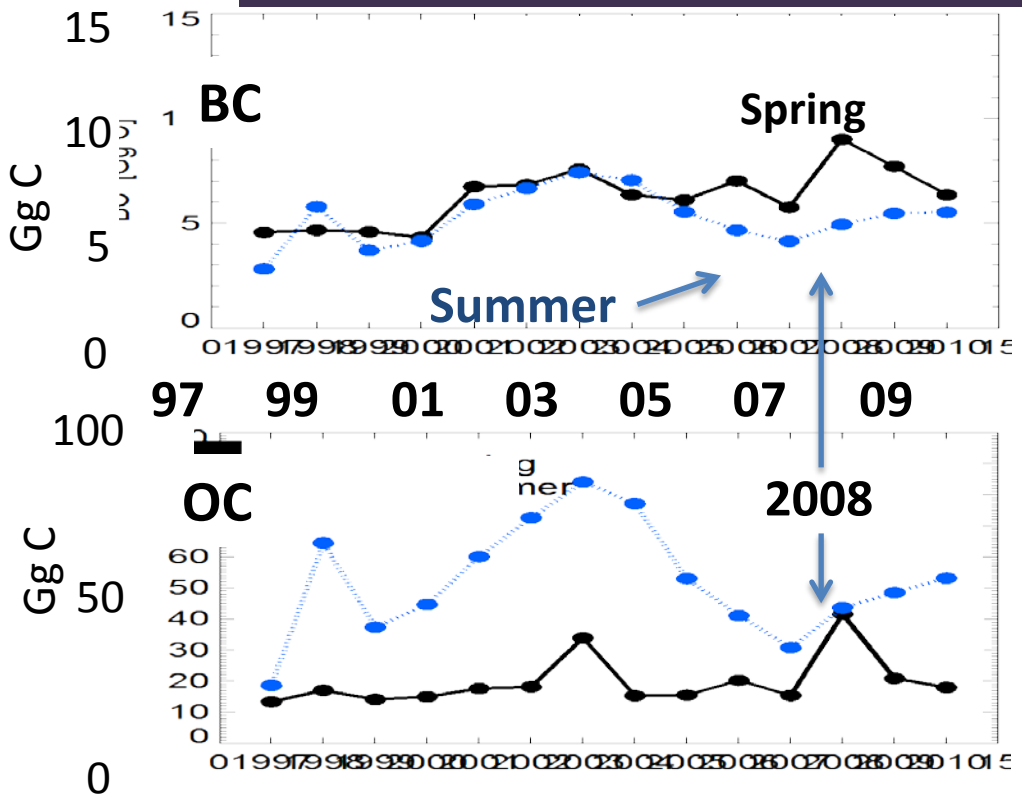
Open Fires were the main source in spring and summer 2008

Significant contribution from non-BC aerosol in spring and summer to AAOD (27%) and Deposition (36%)

Decadal Trends Simulation 1980-2010

- MERRA meteorological fields at 4°x 5° horizontal resolution
- GFED3 open fire emissions for 1997 to 2010 [van der Werf et al., 2010]
- Anthropogenic BC and OC emission trends [Bond et al., 2007] with linear growth scaling factors for Russia and China for 2000-2008 (x2 in 2008)

Preliminary Results 1997-2010 – Simulated Arctic Burdens



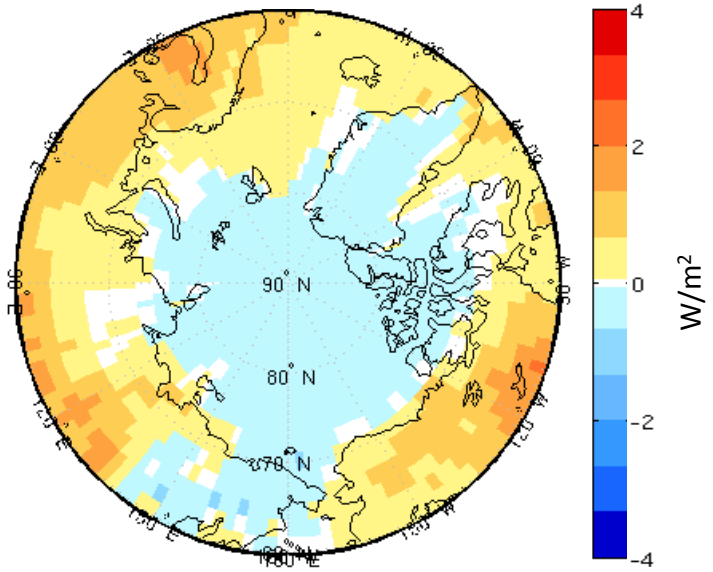
Spring 2008 BC & OC burden was the highest in the 1997-2008 period

Spring 2008 OC burden = 2x the 1997-2010 average (~45% higher for BC)

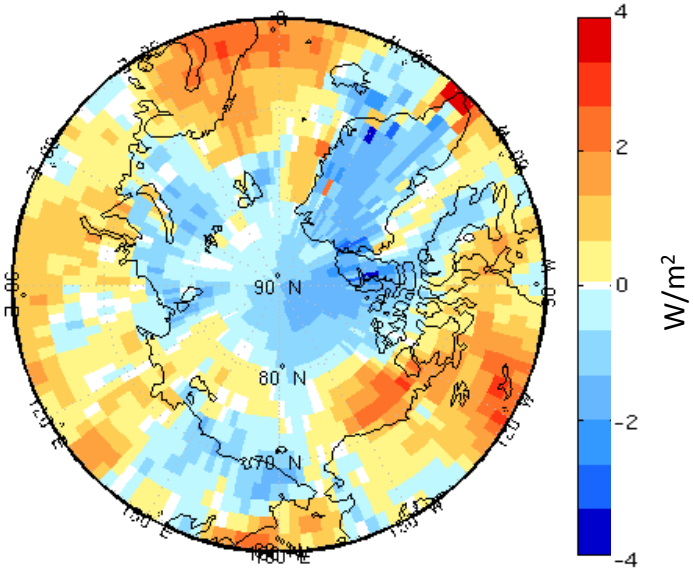
BUT !!! GFED3 open fire emissions are an underestimate

Climate Response

RF@TOA: NCAR - Harvard



F_{TOA}: NCAR - Harvard



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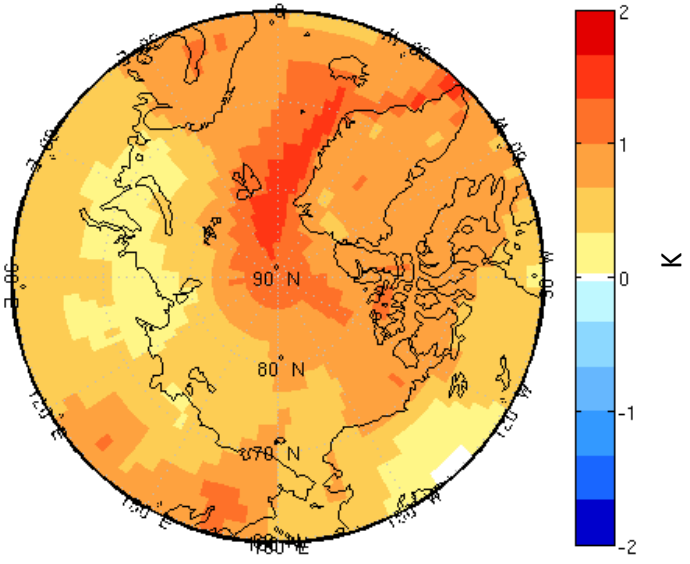


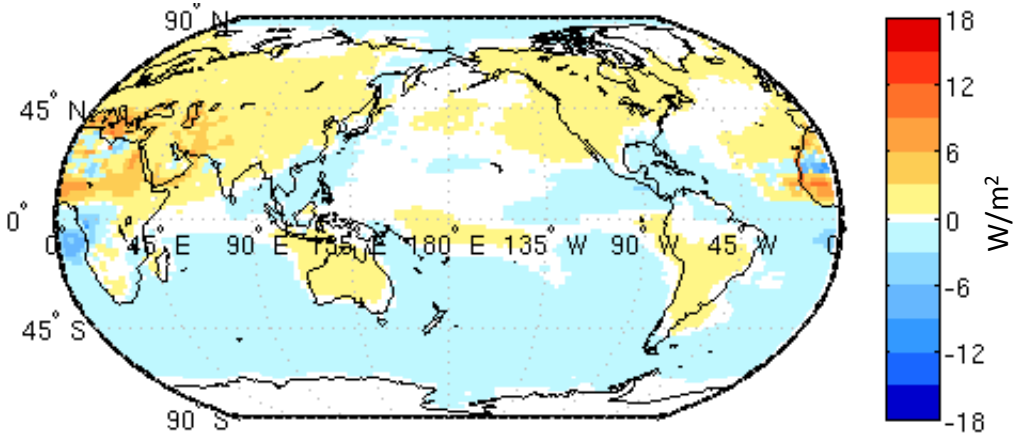
RF: radiative forcing

F_{TOA}: net flux at TOA

TREFHT: surface air temperature at reference height

Climate Response

RF@TOA: NCAR - Harvard



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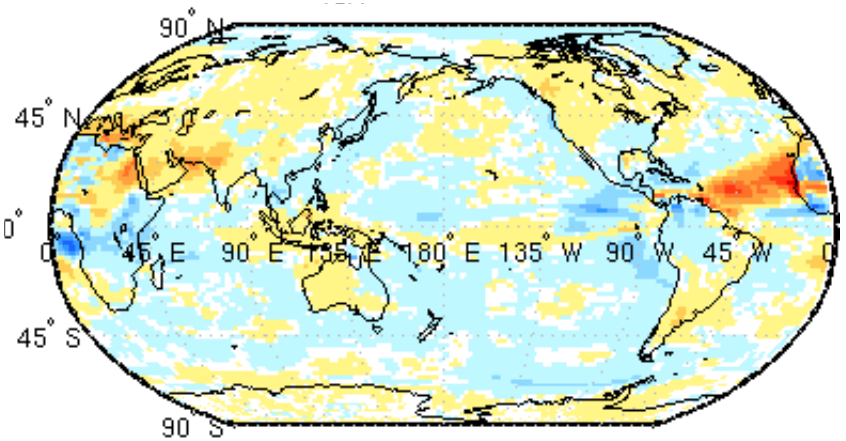

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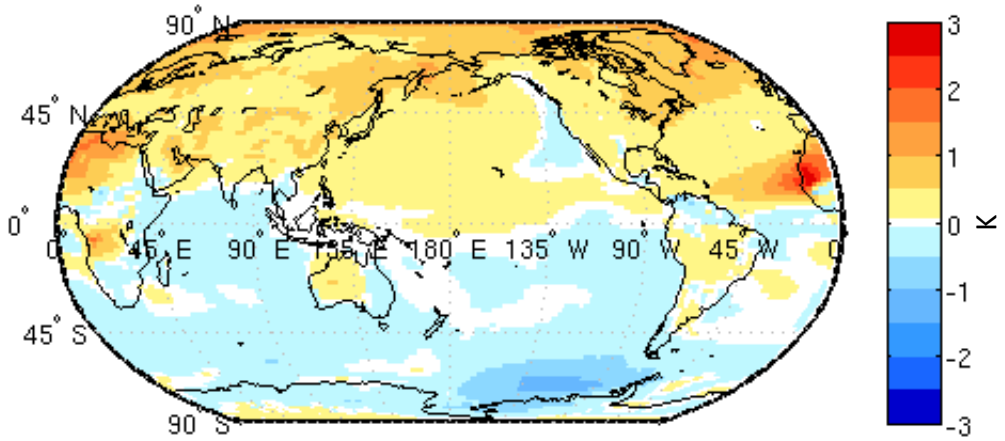

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